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Compétences du Cirad

Améliorer les conditions de production et de vie des agriculteurs des pays du Sud, dans leurs dimensions techniques, organisationnelles, sociales et économiques, est le premier défi et la première mission du Cirad. Du laboratoire au terrain, dans ses dispositifs de recherche en partenariat, il accompagne les producteurs, les différents acteurs et les décideurs publics dans leur adaptation aux changements.

Ces quelques fiches illustrent la démarche et les compétences du Cirad dans ce domaine.

- **Les camélidés - Producteurs du désert.** UMR Selmet
- **Gestion agrosylvopastorale des territoires sahéliens - Place de l'élevage dans la gestion des espaces agroforestiers et forestiers naturels.** UPR BSEF
- **Domestication d'arbres à usages multiples - Techniques de multiplication végétative à faible coût.** UPR BSEF
- **Sélection participative et biodiversité du sorgho *in situ* en Afrique sahélienne.** UMR AGAP
- **Des moyens de lutte efficaces contre la peste des petits ruminants - Vaccin adapté et mobilisation nationale.** UMR CMAEE, UMR Selmet
- **Améliorer les systèmes agroforestiers en zone tropicale humide – Le cas des cacaoyers et des caféiers.** UR Performances des systèmes de cultures pérennes
- **Production durable en agriculture familiale du Sud.** UPR SCA
- **Diffusion des systèmes de semis direct avec couverture végétale à Madagascar.** UMR Innovation
- **Conservation des ressources fertilisantes dans les systèmes d'élevage des pays du Sud - Des pratiques paysannes en évolution.** UMR Selmet
- **Production durable de charbon de bois en République démocratique du Congo - Les jachères arborées enrichies.** UPR BSEF
- **La forêt source d'énergie - Des filières et des procédés utiles au développement.** UPR BioWooEB
- **Les services écosystémiques - Des instruments économiques et politiques uniques.** UMR ART-DEV, Selmet et Tetis ; UPR BSEF et Green
- **Des indications géographiques pour valoriser les produits locaux.** UMR Innovation
- **Accompagner l'essor des filières laitières dans les pays du Sud - Quand les éleveurs font des affaires… UMR Selmet**
- **La viande de porc dans tous ses états - Accompagner les opérateurs pour améliorer la qualité des viandes dans les pays du Sud.** UMR Selmet, UMR CMAEE, UMR Qualisud

Camels

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AGRICULTURAL RESEARCH FOR DEVELOPMENT

Producers of the desert

The large camels (dromedaries and Bactrian camels) are probably the domestic species with the widest range of different functions. Not only do they provide milk, meat and wool (high quality in the case of Bactrian camels), they also provide energy to transport people and goods and for agricultural activities and are used for leisure purposes, be it racing or rides at tourist sites.

Camel herdsman in the El-Obeid region, Sudan. © B. Faye/CIRAD

Mechanical milking of a dairy camel in Saudi Arabia. © B. Faye/CIRAD

Original, popular products

Milk: while consumption is marginal (less than 1% of the milk consumed worldwide), camel's milk plays an original role. It is reputed to have a whole range of therapeutic properties, associated to varying degrees with its composition: it is hypoallergenic (it does not contain beta-lactoglobulin, which causes allergies); it has a hypoglycemiant effect of use to diabetics; it is exceptionally rich in vitamin C and contains highly bioactive lactoferrin, hence acts against harmful bacteria; its lactose is easier to digest; and it is rich in unsaturated fatty acids and minerals.

Local consumption is booming, with demand outstripping supply, as urban consumers appreciate its beneficial effects on health. Production systems are becoming increasingly modern, from promotion of traditional extensive systems to intensive industrial production. Cheese production remains difficult, although recent technological advances have improved its potential.

Meat: camel meat production is low due to the length of the animal's reproductive cycle, but the quality of the meat from animals less than four years old is similar to that of beef, with various dietetic advantages (less cholesterol). The supply chain is largely regionalized, with significant trade flows from Africa to the Near East. Processing is restricted to importing countries (Egypt, Libya, Gulf States, Saudi Arabia), but is a commercial asset for African farmers.

Camel butcher's shop in Maroco. © P. Dugué/CIRAD

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The research that is under way (Sudan, Oman, Saudi Arabia, Tunisia) is aimed at responding better to consumer demand and market opportunities. There are highly efficient pastoral fattening systems, and enclosed fattening installations are being tested (for instance in Tunisia) with a view to producing quality meat.

Milking a Bactrian camel in the steppe, Kazakhstan. © B. Faye/CIRAD

Wool: camel's wool is traded on the international market. Although the market primarily concerns wool from alpacas and other small Andean camelids, Bactrian camel's wool is also used industrially, for instance in Mongolia, where mills offer luxury goods distributors Bactrian "cashmere". Dromedary's wool is less popular, but is often sufficient for local demand and is sold to tourists.

Mongolian camel reared for its wool. © B. Faye/CIRAD

Transport, draught and agriculture

Despite the end of trans-Saharan camel trains, dromedaries are still used to carry non-perishable goods in zones that are inaccessible to vehicles (there are still salt caravans) and camp equipment during large-scale transhumance (in Chad, they can travel several hundred kilometres). They are used to draw water during the dry season or to drive norias. Draught is practised extensively in India, in Rajasthan, and is also observed in Sahelian countries, where dromedaries tend to be used more than donkeys, because of their strength. Camels are also used to transport cereal crops to farmers' houses (chele in Chad). These complementarities are a guarantee of social harmony in countries where conflict between crop and animal farmers may occur.

Camel market in Sudan. © B. Faye/ CIRAD

The main issues

For research, the development of large camelids encompasses four major issues:

- the future of nomadic pastoral societies in the face of climate change and economic globalization, which means making camel products a market commodity;
- food security in countries largely made up of desert, which want to maintain a rural population in the most marginal zones while using some areas solely for livestock farming (excluding oases);
- global warming, which has resulted in the rapid extension of the area in which dromedaries are reared, particularly in Africa, in countries that overlooked the species until less than 20 years ago (Nigeria, Cameroon, Central African Republic, Uganda, Tanzania); camel rearing has spread right up to the fringes of agricultural areas through a switch in species (from cattle to camelids), including among pastoral communities previously centred on cattle farming (Fula, Maasai);
- emerging diseases, a phenomenon linked to the above trends, given that the spread of camel rearing towards the less arid zones of Sahelo-Sudanian Africa brings the animals into contact with a potentially pathogenic environment that differs from the entirely desert zones used previously.

Partners

- Camel and Range Research Center, Al-Jouf, FAO, Saudi Arabia
- DRC, Desert Research Center, Egypt
- IAV, Institut agronomique et vétérinaire Hassan II, Morocco
- IRA, Institut des régions arides, Tunisia
- Al-Farabi University, Almaty, Kazakhstan
- University of the United Arab Emirates, College of Food and Agriculture
- Universities of Khartoum and El-Obeid, Sudan
- University of La Molina and Mountain Institute, Peru
- University of Ouargla, Algeria

When animal farmers turn businessmen...

Supporting the development of dairy supply chains in southern countries

Dairy supply chains in southern countries have really taken off over the past 20 years. CIRAD is supporting these changes through research in partnership in some fifteen countries. Its work is intended to document the boom in the dairy trade, looking at its technical, economic, sanitary, regulatory, social and environmental aspects.

Woman selling traditional dairy products in Kazakhstan. © B. Faye/CIRAD

Green fodder distribution to dairy cows using a water buffalo in Vietnam. © P. Salgado/CIRAD

Changing dairy supply chains and rural territories

The rapid change in the dairy sector in southern countries is proof of the dynamism of family farming, which is increasingly market-oriented. Over the past 20 years, while dairy production has fallen considerably in Europe, it has increased by almost 60% on average in Asia, 45% in Africa and 40% in South America.

This boom in domestic dairy production is a direct response to the rapid growth in demand for dairy products in urban centres. It has been fostered by market liberalization policies and, in most cases, by ambitious dairy development programmes focused on supporting the participation of smallholder farmers in the market economy. However, this restructuring has not had the same impact everywhere. Some regions have emerged as specialist milk producers, while others have resorted to importing powdered milk on a huge scale.

To explain these disparities and encourage family farmers to participate in this thriving trade, CIRAD has been working for 15 years on several research and development projects centring on supporting the dairy sector. Its work is intended to support the development of dairy supply chains and production basins through an integrated approach.

Young Hmong schoolgirl with her milk cartons, Thailand © G. Trebuil/CIRAD

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Milk collection and checking by employees at the Niono dairy in Mali.
© E. Daou

An integrated approach from producer to consumer

Setting up field teams and multi-site research networks has served to boost knowledge of three complementary aspects: innovation within production systems, improved supply chain organization, and support of public policy making.

Encouraging innovation within dairy supply chains is vital in helping smallholder producers access markets and diversify their sources of income. The aim of this first set of research programmes is to foster changes in animal production practices for reducing dry-season milk shortages, cutting feed costs, overcoming sanitary constraints, boosting total deliveries, improving milk hygiene, etc. These studies are being conducted in a wide range of climatic conditions and very different production systems.

Analysing structural changes in local dairy supply chains is another challenge for research in support of the small-scale dairy trade. The aim is to develop overall value chain analysis methods so as to understand the impact of price variations on reorganization of the various distribution circuits, and also to assess the impact of other vital determining factors such as milk quality, collection system organization, professional organization, the emergence of new industries, and local consumer preferences.

Helping the authorities draw up support policies for the dairy sector and livestock territories is the third priority for CIRAD. At a time when the international powdered milk trade is marked by both growing competition and increasing price volatility, this line of research aims to highlight the vital role of public policy in changes in milk production. These research operations are intended to quantify the impact of political measures, for instance those related to tariff regulations or to dairy development programmes, and to come up with tools to support discussions between the various stakeholders involved in the policy-making process.

Cattle fed with Pennisetum purpureum in Madagascar.
© G. Duteurtre/CIRAD

A range of situations reflecting the diversity of local situations

Family dairy farms in the South are now facing new challenges: increasingly stringent sanitary regulations, pressure on resources, and increased competition between operators all pose a threat to the role of small-scale producers in this market. Dairy farms need to be able to innovate if they are to adapt to future constraints.

This new situation means that it is vital to continue research centring on sustainable development of farms, supply chains and territories. The work being done by CIRAD and its partners should make it possible to take a more discerning look at the competition and complementarity between powdered milk imports, family farms and the mega-dairy farms being set up in some southern countries.

Labelling and certification, which encompass the social and environmental aspects of dairy farming, should be promoted in southern countries. In particular, specific regional characteristics and know-how could be promoted better on dairy markets were such quality labels to be widely adopted.

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Partners

South America
• **Brazil:**
EMBRAPA; EMATER-RS, Instituto Paranaense de Assistência Técnica e Extensão Rural (Rio Grande do Sul); EPAGRI-SC, Empresa de Pesquisa Agropecuária e Extensão Rural (Santa Catarina); Federal Universities of Para, Sergipe, Santa Catarina and Rio Grande do Sul
• **Peru:**
La Molina Agrarian University

Sub-Saharan Africa
• **Burkina Faso:**
INERA, Institut de l'environnement et de recherches agricoles; CIRDES, Centre international de recherche-développement sur l'élevage en zone subhumide
• **Mali:**
IER, Institut d'économie rurale; VSFB, Vétérinaires sans frontières Belgium; Cab Demeso; MaliLait
• **Mauritania:**
TIVISKI
• **Senegal:**
GRET, Professionnels du développement solidaire; ISRA, Institut sénégalais de recherche agricole; Laiterie du Berger
• **Chad:**
LRVZ, Laboratoire de recherches vétérinaires et zootechniques

Mediterranean
• **Morocco:**
IAV Hassan II; ENA, Ecole nationale d'agriculture
• **Egypt:**
APRI/ARC Animal Production Research Institute; DRC, Desert Research Centre; University of Ain Shams
• **France:**
INRA, Institut national de la recherche agronomique

Asia and Indian Ocean
• **Réunion:**
ARP, Direction de l'alimentation, de l'agriculture et de la forêt; Sicalait
• **Madagascar:**
FIFAMANOR, Centre de développement rural et de recherche appliquée; Ministry of Agriculture; Tafa,Terre et Développement
• **Vietnam:**
RUDEC/IPSARD, Rural Development Centre/Institute of Policy and Strategy for Agriculture and Rural Development; CASRAD, Centre for Agrarian Systems Research and Development; NIAS, National Institute of Animal Sciences
• **Mayotte:**
ADEM, Association des éleveurs mahorais
• **Kazakhstan:**
Al-Farabi University; agrarian university; Antigen, Food Master and Danone firms

Quality improvement in the pork sector

Helping operators improve meat quality in the South

Over the past 20 years, pork consumption has doubled in Africa, Asia and South America. The sector, which is booming in developing countries, has to adapt to new demands from both consumers and distribution circuits, in terms of nutrition and safety. CIRAD is working to support these changes, primarily in the southern Indian Ocean (Réunion, Madagascar, etc)..

© V. Porphyre/CIRAD

Small periurban pig farm in Antananarivo, Madagascar.
© A. Bretaudeau/CIRAD

Some 80% of pork production is concentrated in Asia and Europe, and it accounts for more than a third of the meat eaten worldwide. In view of the high productivity and ability to adapt of pigs, pork is often one of the cheapest meats available. There are many types of production systems, from traditional family-based systems to highly intensive ones. The work being done by CIRAD and its partners is aimed at improving production techniques, monitoring pathogens and contami-nants, mastering traditional processes and implementing quality approaches.

Good production practices for quality meat

The end quality of pork depends on the genetic potential of the animals, their diet, their health, production practices and wellbeing during rearing and slaughtering. CIRAD's researchers are working to guide farmers towards good practices and help them:

- optimize the use of local feed sources;
- promote the use of hardy races suited to difficult climatic conditions;
- identify sustainable production practices to produce safe meat that corresponds to consumer tastes (less fat);
- work with local players to draft good practice guides appropriate to situations in developing countries.

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Monitoring and controlling pathogens and contaminants

Sausage production in northern Vietnam. © V. Porphyre/CIRAD

Before drafting control and prevention plans concerning the health risks of pork, stakeholders from the supply chain and the veterinary public health sector need reliable, up-to-date information on the pathogens in circulation at any given time and the appropriate measures. CIRAD and its partners are particularly interested in Salmonella, Campylobacter, Listeria and Escherichia coli type bacteria, which are antibiotic-resistant, and in meat parasites (tapeworms). They also monitor the presence in meat of antibiotic residues due to misuse of drugs during the rearing stage, and of chemical contaminants, polycyclic aromatic hydrocarbons (PAHs) that appear during the meat smoking process. This involves:

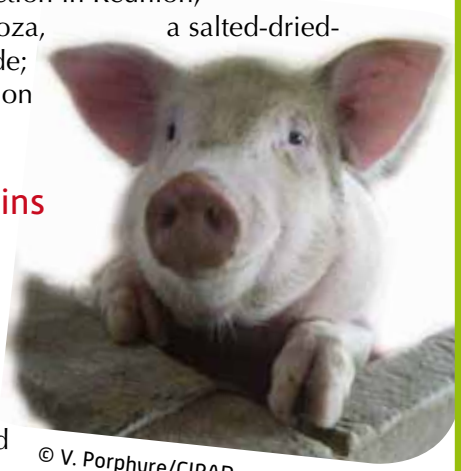
- monitoring pathogens and contaminants (health surveillance and alert systems);
- identifying risk factors on farms, within the supply chain and within territories;
- modelling and assessing plans aimed at controlling and preventing the health risks linked to pork products.

Butcher in Antananarivo, Madagascar. © V. Porphyre/CIRAD

Characterizing and developing traditional processing techniques

Meat product preservation and processing techniques are the fruit of local know-how, which is often ages old and conveys a strong image of authenticity. While respecting gastronomic cultures, CIRAD's research is aimed at improving salted, dried and smoked meat product quality. The organization is working on:

- characterize traditional boucané (smoked meat) production in Réunion;
- the rediscovery of the traditional process by which kitoza, a salted-dried-smoked meat product widely eaten in Madagascar, is made;
- the development of an innovative hot-smoker, based on separating the drying, cooking and smoking stages



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Promoting quality approaches in supply chains

Pork supply chains involve a range of operators, from rearing, transport, slaughtering and processing to sale to consumers. In difficult economic circumstances, improving the quality of the products offered to consumers means covering the whole of the supply chain. CIRAD thus strives to look at the strategies adopted by all the players in the chain, by:

- assessing economic exchanges and the conditions for change within chains;
- modelling social networks and product fluxes;
- conducting socioeconomic analyses of players to identify the obstacles to and levers for the development of quality supply chains

Sharing research results

As it is essential to disseminate the results of research, CIRAD hosts an information gateway, Pigtrop (http://pigtrop.cirad.fr), which gives access to the latest news and research results concerning pork production in the South. The website, which is an FAO collaborating partner, is intended for researchers, students, professionals, farmers and development bodies interested in the sustainable development of pork supply chains in warm regions.

Partners

Indian Ocean

- **Réunion:** Chamber of Trades and Crafts; CRITT/CCI, Centre de ressource et de transfert technologique ; pork producer cooperatives; CRVOI, Centre de recherche et de veille sur les maladies émergentes dans l'Océan Indien; Cyclotron de la Réunion ; FRCA, Fédération régionale des coopératives agricoles; IRQua, Institut régional de la qualité; Qualitropic, a competitiveness cluster on agro-nutrition in the tropics

- **Madagascar:** Veterinary Services Directorate; FOFIFA, National Centre of Applied Research and Rural Development; Institut Pasteur de Madagascar; University of Antananarivo

- **Mauritius:** Food Technology Laboratory; University of Mauritius

Europe

- **France:** ANSES, Agence nationale de sécurité sanitaire; ARCOS (drying, cooking and smoking equipment manufacturer); INRA, Institut national de la recherche agronomique; Montpellier SupAgro; UMR CNRS 52 95, Institut de mécanique et d'ingénierie de Bordeaux

- **United Kingdom :** RVC, Royal Veterinary College, University of London

Effective control methods against peste des petits ruminants

Adapted vaccine and national mobilization

The vaccine developed by CIRAD and its partners against peste des petits ruminants (PPR) is the outcome of work undertaken as early as 1980. Today, it remains the most effective way of controlling this destructive disease. The mass campaign undertaken with the Moroccan production company, Biopharma, and the Moroccan veterinary services in 2008 helped to "save" the Eid celebrations–and the country in the long term–under appropriate economic conditions.

Goat affected by PPR with scabs at the corners of the lips. © H. Salami

Restraining of a goat with PPR by inhabitants of the village of Nguekhokh near Thiès, Senegal. © H. Salami

Peste des petits ruminants (PPR) is a highly contagious infectious disease of viral origin that affects small domestic and wild ruminants. To date, it is the most widely propagated disease in goats and sheep: it affects a billion animals in Africa, Asia and the Middle East.

An economically damaging global disease

PPR was described for the first time in Côte d'Ivoire in 1942. Several clinical cases were then declared, gradually, in other regions of West Africa. Its presence was then confirmed in Nigeria, Senegal and Ghana. It seemed that the epidemic was confined to the west of the continent, until a disease affecting goats occurred in Sudan in 1972. It was first diagnosed as rinderpest, but was later confirmed to be PPR.

It is only recently that the true extent of the disease has been determined, but it is still spreading in Africa, India and in other regions of West and South Asia.

A zone where PPR is rife, in Niayes. Village of Kassack, Senegal. © H. Salami

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Development by CIRAD of an effective vaccine

Vaccines and preparations for the Moroccan campaign. © Biopharma

PPR can cause considerable economic damage through the death rates it causes–between 20 and 80%. At the beginning of the 1980s, CIRAD took the initiative to develop an attenuated vaccine in conjunction with the Pirbright Institute for Animal Health (IAH, United Kingdom). The vaccine was obtained by the successive passage of the Nigeria 75-1 virus strain on cell cultures. Its effectiveness was established between 1989 and 1996 in large-scale trials involving over 98,000 animals during the development phase.

To date, this vaccine is the most effective way of controlling the disease. It provides at least three years of immunity, i.e. more than the average economic life span of small ruminants. It has now been used for twenty years and has proved its scope, its easy inoculation and its low large-scale production cost. In addition, improved freeze-drying methods have enhanced its stability in the production phase, and during its reconstitution under hot climatic conditions.

Biopharma bioreactor. © Biopharma

The Moroccan crisis confined within a few weeks

PPR was first reported in Morocco in July 2008. The Moroccan authorities then urgently requested CIRAD's support in preventing a social and economic crisis with the approaching Eid celebrations in December when 5 million sheep were due to be ritually slaughtered. CIRAD immediately sent the master seed strain of the PPR vaccine to a private national laboratory, Biopharma, in close collaboration with the Moroccan veterinary services.

Biopharma was able to produce 25 million doses of the vaccine in a few weeks. The Moroccan veterinary services then organized a mass vaccination campaign involving 20 million sheep before the celebration. At the same time, epidemiological investigations were carried out and a strain of the PPR virus was isolated in CIRAD's laboratories in Montpellier. After partial genome sequencing, it appeared that the incriminated virus came from lineage IV, of Asian origin. No infection was reported after the vaccination campaign, but further mass campaigns were organized in 2009 and 2010.

Expertise to be transferred

The cost price of producing the vaccine was judged to be of interest by the Moroccan State and much cheaper than procuring supplies on the international market which, moreover, would have been unable to supply the vaccines in the time available. The lead time time was considered acceptable by the veterinary services, which were effectively able to begin vaccinating the sheep less than two months after the infection was declared.

The Moroccan veterinary services, Biopharma and CIRAD propose to transfer their experience to countries affected by this disease.

Selection of sheep in their pen for samples to be analysed, village of Déali,near Dara, Senegal. © H. Salami

Partners

- **Austria:** FAO/IAEA, Joint division of nuclear techniques in food and agriculture
- **Morocco:** veterinary services, Biopharma
- **Portugal:** IBET, Instituto de Biologia Experimental e Tecnológica
- **United Kingdom:** IAH, Institute for Animal Health

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Agrosilvopastoral management of Sahelian lands

Role of animal production in agroforest and natural forest management

© R. Peltier/CIRAD

In the past, the natural vegetation of Sahelian landscapes comprised wooded grasslands on the slopes and various types of forest in the valleys. Nowadays, in every inhabited zone, most of the deep soils have been cleared and are now cultivated. Cohabitation between crop farmers and other users of these areas (particularly stock farmers), who often have conflicting interests, is sometimes fraught. However, through various projects, CIRAD researchers have shown that these groups can organize themselves and come up with land management solutions that optimize any possible synergies

Young shepherd leading his herd through a forest area used for fuelwood production, in Niger.
© R. Peltier/CIRAD

Dunes, hills and dry plateaus, which are often stony and difficult to cultivate, serve as collective areas for grazing, hunting and gathering, particularly of wood. Copses and small areas of bottomland forest have in some cases been preserved around ponds and on riverbanks. The farmers, for their part, have almost all kept in their fields a few trees they see as useful and not too much of a problem for their crops.

Livestock is led into uncultivated areas during the rainy season, and as harvesting progresses, into fields to eat straw and other crop residues. Throughout the year, the animals thus eat both herbaceous plants and "aerial fodder" on trees (leaves, bark and young shoots, flowers and fruit). The latter is particularly important towards the end of the dry season, once all the herbaceous biomass has dried: the animals need the nitrogen in the aerial fodder to digest straw.

However, free livestock movements within these landscapes are increasingly hindered, if not prevented, by the densification of crops and animals and the specialization and privatization of various areas. This has adverse effects on the functioning of the various agrosilvopastoral systems, and can cause very serious socioeconomic problems.

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Integrating animal production into harvested forests

Certain areas are steadily being appropriated by woodcutters' organizations. This is the case in Niger and Mali, where CIRAD has supported the introduction of a local natural resource management policy and the creation of woodcutters' associations and rural fuelwood markets. Unfortunately, those groups sometimes have a tendency to exclude stock farmers, claiming that their animals damage trees, particularly stump sprouts. However, scientists have shown that livestock in fact has a very limited impact on tree survival and growth in the Sahel. On the contrary, grazing during the rainy season primarily concerns the herbaceous layer and in fact reduces dry season fire damage to trees. Lastly, stock farmers are objective allies of forest users in the fight against excessive clearing.

Faidherbia albida parks are a perfect example of a positive combination of animal and crop farming and wood production. © R. Peltier/CIRAD Partners

Could access to fodder be traded for fertilizing fields?

Some stock farmers have settled partially and are practising agriculture. At the same time, crop farmers have acquired animals and are increasingly claiming exclusive ownership of their plots and keeping straw and tree products solely for their own animals, particularly in densely populated areas. However, there are still regions in which farmers have very few animals, and any agrosilvopastoral areas are still under-used for animal production. In such areas, untrimmed trees may become a hindrance to crops and be logged. It is thus crucial to recommend introducing as widely as possible management methods that encompass the many uses of areas and of their resources, based on traditional service and product exchange practices (fodder for manure, also cereals for milk, etc).

Discussion between stock and crop farmers concerning joint land management in a village in northern Cameroon. © R. Peltier/ CIRAD

Preserving stock farmers' access to springs and bottomland water points

Riverside and bottomland forests are often cleared to plant market garden or flood-recession crops, orchards or timber trees, which deprives animals of access to water points in the thick of the dry season, or causes the water points to dry out. This intensification of fertile and irrigable zones may be legitimate as far as the crop farmers are concerned, but the traditional, administrative and political authorities also need to take account of the irreplaceable value of these unique landscapes and their key role for wildlife and livestock.

Bottomland *Acacia nilotica* forest, which is key to the animal production system practised in a valley in Niger. The system is under threat from uncontrolled clearance for farming. © R. Peltier/ CIRAD

Setting up negotiating platforms for multi-use land management

Cohabitation between the different users of a given area, who often have conflicting shortterm interests and customs, is not easily managed. Through various projects, researchers from CIRAD have shown that these groups can organize themselves, begin talks, come up with scenarios and find land management solutions that optimize any possible synergies. This involves creating and supervising negotiating platforms and conducting multi-stakeholder modelling. Generally speaking, taking account of the pastoral value of trees helps to ensure management methods that preserve biodiversity, and indeed biomass carbon stocks, more effectively, while providing local people with more diversified sources of income and helping to keep the peace between the different human groups concerned.

Partners

- European Union (EuropAid)
- IRAD, Institut de recherche agricole pour le développement, Cameroon
- INRAN, Institut national de la recherche agronomique du Niger

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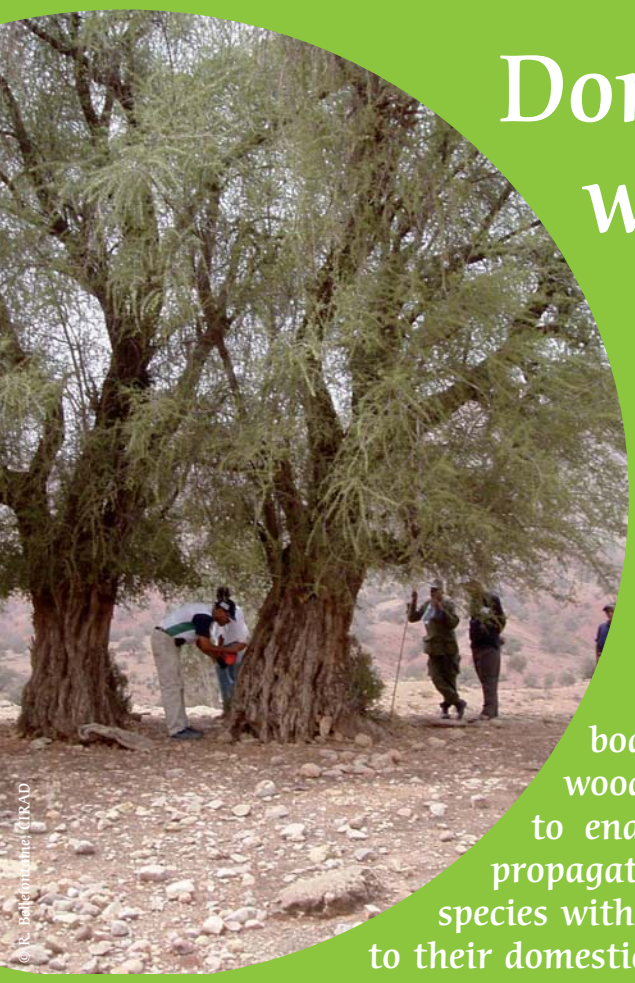
AGRICULTURAL RESEARCH FOR DEVELOPMENT

Domestication of trees with multiple uses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Low-cost vegetative propagation techniques

The main aim is to regenerate forest areas in the Mediterranean or the semi-arid tropics, without using expensive means. The proposed techniques are easy for local people to take on board, and enable them to regenerate the most appreciated woody species, which have become scarce. The second aim is to enable rural people or traditional healers to select and propagate high-performance clones themselves, for certain species with multiple uses (medicinal, wild fruits, etc), with a view to their domestication.


Introduction to grafting, Morocco.
© R. Bellefontaine, CIRAD

Maintaining vital species

In most semi-arid zones, wood resources are under-used. There are many reasons, but they are always the same: agricultural pioneer fronts with the arrival of migrants, growing numbers of animals on a small area, and bush fires caused by beekeepers or hunters. Natural seedlings survive for just a few months, and subsequently almost all die (upwards of 95%) during the dry months. Nursery seedlings and industrial plantations are too expensive, except in a very few cases, when the women of a village decide to plant local species by sowing non-selected seeds on small areas and protecting them with a fence. Farmers also use low-cost vegetative propagation techniques to domesticate ortets they have selected. These techniques serve to maintain vital local species or highly appreciated clones on a small scale. They are both simple and economic: inducing suckering, taking root segment cuttings, terrestrial layering and macrocutting. Other techniques, such as aerial layering and conventional cuttings, require a day's training; grafting and herbaceous cutting (in an artificial fog) call for more detailed knowledge. Local groups can afford this type of equipment.

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Argan *(Argania spinosa)* ortet produced *ex situ* by grafting. © R. Bellefontaine, CIRAD

Inducing suckering, layering and cutting

Suckers, which are often obtained after root wounding, are aerial shoots newly formed on roots generally between 5 and 15 cm below the soil surface. They may be found up to 80 metres from the mother tree (Prunus avium, Sorbus torminalis). Suckering ability varies from one species to another. For instance, more than 310 African woody species produce suckers. Using a root segment (cutting), which is removed and placed in a suitable substrate, it is easy to produce trees (for instance cork oaks, Sclerocarya birrea, Detarium microcarpum, etc). Other woody species have low-hanging branches that root (terrestrial layering) if buried in or in contact with the soil (Alchornea cordifolia layers up to 10 metres from the mother tree). These techniques make it possible to rejuvenate ortets selected by generations of farmers and propagate them in their fields.

Aerial layering of *Solanecio mannii* (medicinal use), Uganda.
© Q. Meunier, University of Gembloux

Sucker on a root of *Diospyros mespiliformis* (African ebony, fruit and medicinal species) in northern Cameroon. © R. Bellefontaine, CIRAD

The first stages of domestication: argan in Morocco

In the semi-arid regions of southwestern Morocco, no argan variety has yet been domesticated. CIRAD has succeeded in mobilizing genotypes between 200 and 400 years old by grafting and aerial layering. Herbaceous cutting in an artificial fog has also made it possible to make optimum use of the considerable variability seen in the field. At the same time, by improving nursery techniques, it has also been demonstrated that raised stands with WM-type fluted containers enable the roots to self-prune and foster the formation of a dense root system, which significantly reduces mortality rates in the field, and boosts juvenile growth. In view of this, rest-rotation grazing periods can now be shortened, mixed farmers are prepared to accept very short rest-rotation grazing periods for areas regenerated using improved clones, and a start can be made on gradually domesticating ortets with remarkable characteristics that are recognized and preserved by local people.

Diospyros mespiliformis fruits in Burkina Faso.
© M. Arbonnier, CIRAD

Partners

- INERA, Institut de l'environnement et de recherches agricoles, Burkina Faso
- University of Ngaoundéré, Cameroon
- INRAN, Institut national de recherches agronomiques du Niger
- Centre régional de recherches forestières de Marrakech and University of Marrakech, Morocco
- University of Lomé, Togo

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AGRICULTURAL RESEARCH FOR DEVELOPMENT

Participatory breeding in Sahelian Africa

and *in situ* sorghum biodiversity

© A. Oualbéogo

In Sahelian Africa, sorghum is a staple food crop in the diet of rural populations. To cope with population growth, urban food requirements and climate change, agricultural production needs to increase, particularly that of sorghum, whose substantial diversity helps ensure the resilience of local farming systems. CIRAD and its African partners are working to tackle this challenge, by making optimum use of that biodiversity and of related knowledge among farmers.

Discussion with a group of women of the criteria for choosing sorghum plants, Burkina Faso © G. Trouche, CIRAD

Characterizing sorghum agro-biodiversity and understanding its evolution

Ex situ collections are a major source of variability for adaptation and quality characters. Breeders initially explored ex situ collections of sorghum varieties from Sahelian Africa, to assess the range of adaptation characters and the yield potential of the varieties: plant adaptation to different soil types, adjustment of the crop cycle to the rainy season as a result of photoperiodism, resistance to the main pests and diseases, grain to straw ratio, drought tolerance, and straw and grain quality for a range of food and non-food uses.

Knowledge of the in situ dynamics of diversity in both spatial and temporal terms is of use in drafting biodiversity management strategies. Most African farmers still use traditional varieties that are well suited to their environment and different uses. However, changing lifestyles and the spread of cash crops and of maize are a threat to the current diversity of sorghum varieties. The risks of genetic erosion could also be exacerbated by the multiplication of climatic hazards and current changes in seed supply systems.

Most of the agro-ecosystems in which sorghum is grown include wild sorghum varieties, which play a role in the evolution of the diversity of cultivated varieties. Identifying these wild populations, which are under threat from increased land use pressure, and conserving them in situ, is a major priority, since they have potentially useful unique genes.

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In the course of their research on sorghum agro-biodiversity, the various partners have developed new methods, knowledge and genetic material:

› The constitution of unique collections in various countries (Burkina Faso, Mali, Niger, Guinea), and the compilation of a substantial amount of related information (local knowledge, production ecology of different varieties, uses, genetic markers, morphological characterization, etc), will be of use in eco-geographical zoning of wild and cultivated varieties and modes of conservation.

› A clearer understanding of how traditional seed supply systems (seed exchange and access networks) function and of their impact on in situ diversity. In Mali, for instance, the situation varies considerably, from maintenance of traditional varieties to regular adoption of new ones, whereas in Niger, there have not been any major varietal changes in the last thirty years, in spite of environmental and manmade pressure.

Participatory evaluation of sorghum lines, Burkina Faso
© K. Vom Brocke, CIRAD

› Better knowledge of farmer practices, particularly in terms of varietal choices and seed recycling, and of their influence on the dynamics of diversity. Local varieties are "population-varieties" that probably have an advantage over pure lines in terms of adaptation, at least in marginal environments.

Establishing participatory breeding programmes

Participatory breeding means involving farmers and other stakeholders in the supply chain fully in the varietal development process, so as to satisfy their requirements better. In the case of sorghum, the aim is to make optimum use of the rich local biodiversity in breeding programmes established jointly by researchers and farmers. The skills this builds serve to:

› work with farmers, both men and women, to identify and rank the different breeding criteria, and then to assess and breed varieties based on those criteria so as to satisfy their immediate requirements;

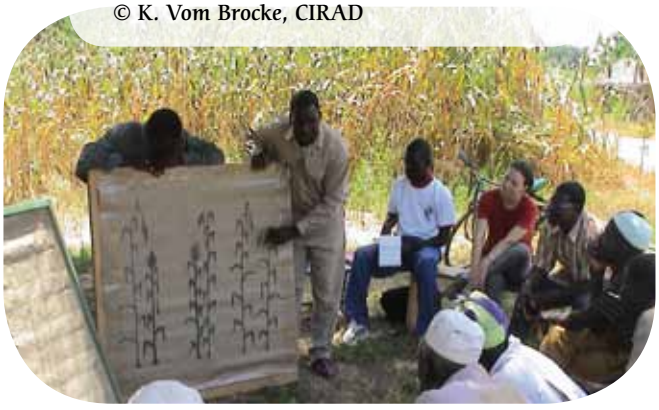
› create populations that encompass the local genetic diversity farmers want;

› develop participatory recurrent selection methods based on those genetically diverse populations, for use in farmers' fields;

› organize training and consultation workshops to exchange experiences and share decision-making throughout the process;

› help farmers' organizations produce and distribute seeds (training, handbooks).

Training producers in Zikiémé, Burkina Faso
© K. Vom Brocke, CIRAD



Evaluation of panicles suitable for beer production, Burkina Faso
© K. Vom Brocke, CIRAD

Partners

- **Burkina Faso:** AMSP, association Minim Song Panga innovative farmers' network), Sanmatenga; INERA, Institut de l'environnement et de recherches agricoles; UGCPA/BM, Union de groupement pour la commercialisation des produits agricoles, Boucle du Mouhoun
- **Mali:** AOPP, Association des organisations paysannes professionnelles; IER, Institut d'économie rurale
- **CGIAR:** ICRISAT, International Crops Research Institute for the Semi-Arid Tropics
- **Donors:** ANR, Agence nationale de la recherche, FFEM, Fonds français pour l'environnement mondial, France; McKnight Foundation, CCRP, Collaborative Crop Research Program, USA; European Union (EC-IFAD, ECOWAS); Fondation Agropolis

For further information

Vom Brocke K., Trouche G., Weltzien E., Barro-Kondombo C.P., Gozé E., Chantereau J. 2010. Participatory variety development for sorghum in Burkina Faso: Farmers selection and farmers criteria. Field crops research, 119 (1) : 183-194.

Website:
http://selection-participative.cirad.fr/

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AGRICULTURAL RESEARCH FOR DEVELOPMENT

Improving agroforestry systems in the humid tropics

The example of cocoa and coffee

© D. Snoeck, CIRAD

In humid tropical zones, agroforestry systems (AFS) combine forest trees with cash crops (coffee, cocoa, rubber, oil palm, etc), fruit trees (cola, avocado, orange, etc) or food crops, or animal production. These AFS are generally natural forests in which some of the original vegetation has been replaced by other perennial species after slash-and-burn clearing of the forest to plant food crops. After a few years, such development results in production systems with multiple outputs, which are managed depending on the cash crops being grown, since they generally provide the major share of farmers' income.

Against a backdrop of reduced cultivable land availability, increasing population pressure, food crises, climate change, and the fact that conventional intensification of agriculture has now reached its limitations, agroforestry practices offer interesting prospects. Improving management of such systems and ensuring their environmental, technical and social sustainability is a major issue for research and development.

"Nacional" cocoa tree, Ecuador
© M. Dulcire, CIRAD

Understanding how multi-functional AFS work...

Cocoa- and coffee-based AFS are traditional production systems, which function in much the same way as forest. Compared to monoculture systems, they produce less cocoa or coffee, but they are more sustainable and environmentally friendly, since they are less intensive in terms of pesticides and chemical fertilizers. Farmers also produce other goods for their own consumption or for sale (various fruits, palm oil and wine, medicinal products, fodder, timber and craft products). AFS also provide a range of important environmental services, such as biodiversity conservation, soil fertility preservation, and carbon sequestration. They also play a social and cultural role (family, national and international heritage, landscape appearance and sacred sites).

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Cocoa *(Theobroma cacao)* and coffee (*Coffea canephora and Coffea arabica)* are understorey species, hence the shade provided by other species in AFS is naturally favourable (regulation of the microclimate, supplies of organic matter). However, shade can also have adverse effects, for instance by creating conditions that favour disease development. In cocoa-based AFS, shade reduces attacks by insects such as mirids, but favours black pod disease, while in coffee-based AFS, it lengthens the cherry ripening period, which improves coffee quality but reduces yields. It is thus by adjusting the degree of shade in a plot that farmers can balance the positive and adverse effects of combining other trees with cocoa or coffee.

Coffee trees on the leeward coast of Guadeloupe
© M. Dulcire, CIRAD

... so as to boost their performance and sustainability

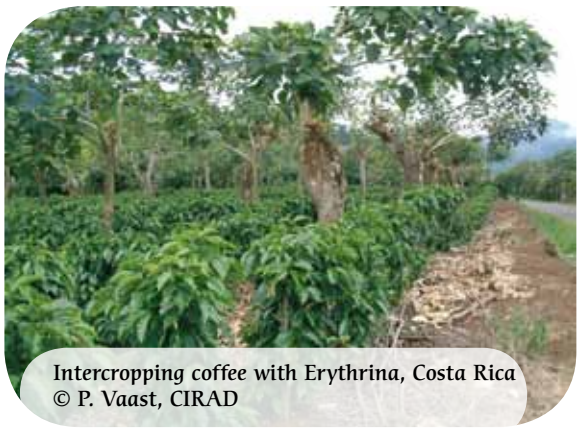
CIRAD is conducting research in several countries aimed at enhancing these complex cropping systems, whose maintenance and multi-functionality depends on the management choices made by farmers. AFS performance is being assessed to understand the compromises farmers have to strike between the products and the different services provided by such systems, to identify the levers that could be used to improve them. Solutions are being tested in response to specific constraints and objectives. The work currently under way is aimed at developing innovative systems in a context of ecological intensification and climate change.

The aim is also to develop tools and methods, on the one hand to assess the ecosystem services provided by AFS, and on the other hand to design agroforestry intercropping models capable of stabilizing or even increasing incomes among rural households.

Understanding and supporting the development of AFS means analysing local know-how and strategies and practices among the different stakeholders involved in the cocoa and coffee supply chains. Research is also looking at innovation processes, changes in supply chains, and the landscape impact of AFS.

Research in response to change

CIRAD is analysing how agroforestry can contribute to the viability of household activity systems in a context of economic, climate and environmental change. Comparative analyses of different local histories allow researchers to:



Intercropping coffee with Erythrina, Costa Rica
© P. Vaast, CIRAD

> measure the impact of AFS on household economics, land ownership and the environment;
> assess the flexibility of household activity systems in the face of change (diversification of outputs, biodiversity management methods, use of environmental services);
> question the development models promoted by public policy.

Partners

- DP Agroforesterie, Cameroon (IRAD, University of Dschang, University of Yaounde 1)
- DP Agroforesterie, Central America (CATIE, INCAE, Bioversity International, PROMECAFE, CABI)
- **Cameroon:** IRAD, Institut de recherche agricole pour le développement
- **Costa Rica:** CATIE, Centro Agronomico tropical de Investigacion y Ensenanza
- **Ghana:** Kwame Nkrumah University
- **Ivory Coast:** CNRA, Centre national de recherche agronomique; University of Cocody
- **Kenya:** ICRAF, World Agroforestry Centre; CRF, Coffee Research Foundation
- **Uganda:** University of Makerere

For further information

AFS4Food project, agroforestry for food security:

http://AFS4Food.cirad.fr

Sustainable production for small scale farmers in developing countries

Designing **innovative cropping systems**


© E. Scopel, CIRAD

Tropical environments generally have fragile soils and aggressive climates. Predictive climate change models agree that the instability of climatic conditions is likely to increase, with more frequent droughts or catastrophic flooding. The poorest producers find it difficult to access credit and markets, which, moreover, do not provide them with a sufficient return. In view of this, CIRAD is working to develop innovative systems that protect and make optimum use of the natural resources available in the short and long term, which stabilize and maintain if not improve productivity and limit the environmental impacts of agricultural activity.


Participatory establishment of specifications for innovative new DMC systems, Brazil.
© J. H. Valadares Xavier, CIRAD

The agronomic processes and ecological services used

The proposed cropping systems centre on direct seeding mulch-based cropping (DMC). They aim to minimize the natural physical, chemical and biological degradation of soils as a result of their cultivation, and are based on diversifying the species cultivated in rotation, succession or even association (intercropping).

Introducing cover crops into these systems provides a range of services:

- nutritive substrate for the soil fauna and the crops grown;
- increased primary biomass production due to the solar energy intercepted between two crop cycles and at the start of the main crop cycle (cereals, soybean, cotton, etc);
- recycling of nutrients, which permeate the deeper soil horizons thanks to the plants' dense, deep root systems;
- water regulation, linked to the total, permanent protection of the soil, which reduces runoff;
- control of diseases, insect pests and weeds, whose habitat is modified;
- supplies of food and animal fodder.

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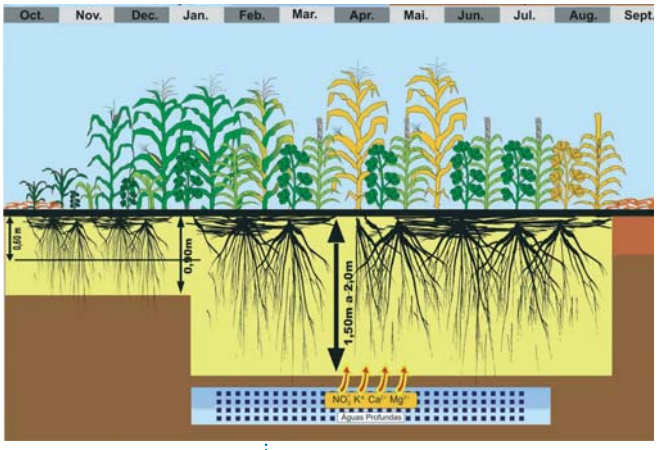
On a farm scale

However, implementing DMC with a view to a given service means for farmers striking a delicate balance between various ecological processes. This requires from them greater knowledge of the impact of cropping techniques on that balance between processes, so as to manage them better and thus achieve the relevant agricultural and ecological objectives. Developing the use of live covers requires specific knowledge tailored to the local situation in terms of the environmental conditions and the stakeholders involved in agricultural production.



DMC systems involve cover crops grown in succession, relay or association with the main crops so as to make optimum use of the resources available in time and space. © E. Scopel, CIRAD

Moreover, this type of complex innovation means making substantial changes to how resources are used on farms, to how operations are organized, and can result in the diversification of the products generated and the sources of income. Such changes are not always acceptable to some producers. In the case of Vietnam, for instance, farmers' motivation to practice DMC rather than traditional upland rice or maize production systems is determined by their ability to cope with the additional cost of the technique, particularly in terms of labour.

New systems for and with producers

The evaluation and conception process around DMC systems thus largely depends on the points of view of the players locally involved in rural development, and particularly those of the different types of farmers who are prompted, by choice or necessity, to show an interest in this type of cropping system. Because of these considerations, CIRAD has chosen participatory methods to develop innovative cropping systems in conjunction with its partners. This type of approach helps considerably to familiarize producers with new technical proposals and facilitates the cross-learning required for efficient management of such systems.

CIRAD is working with producers in several tropical regions to build new cropping systems:

- in central Brazil, for the small farms resulting from the agrarian reform in the Cerrados;
- in the hills of northern Vietnam, for small mountain farms, following the ban on slash-and-burn;
- in Zimbabwe and Mozambique, with cereal and cotton smallholders in the local savannahs;
- in Madagascar, with rainfed rice smallholders in mid- and high-altitude zones;
- in Mali, Niger and Guinea, with smallholders in semi-arid zones.

Monitoring plant growth in a maize-based DMC system, Vietnam. © F. Affholder, CIRAD

Partners

- FOFIFA, National Centre of Applied Research and Rural Development, Madagascar
- EMBRAPA Cerrados, Brazilian Agricultural Research Corporation for the Cerrados region
- VASI, Vietnam Agricultural Science Institute
- IIAM, Mozambique National Institute of Agronomic Research
- Montpellier SupAgro, France
- INRA, Institut national de la recherche agronomique, France
- IRD, Institut de recherche pour le développement, France

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Dissemination of direct seeding mulch-based cropping systems in Madagascar


© E. Penot, CIRAD

Developing a **learning approach**

In the mid-altitude zones of Madagascar, cropping systems based on direct seeding, with a cover crop and crop rotation, have been disseminated on smallholdings since the turn of the century with a degree of success. In order to disseminate these new cropping patterns, CIRAD and its development partners in Madagascar have developed modelling tools to monitor and assess activities through a DSS (Decision Support System). For developers, these tools provide decision-support in the technological choices to be implemented depending on their physical environment and their type of farm.


Field visit and assessment of practices. © E. Penot, CIRAD

Optimizing extension efforts

In agricultural development projects, decision-support and negotiation between operators and with farmers is a priority, so that actions live on after the end of the project. CIRAD is endeavouring to optimize extension efforts by proposing techniques and services that are truly adapted to each type of farmer.

This type of initiative is being implemented as part of development projects in the regions of Lake Alaotra (BV-lac project, Lake Alaotra watersheds), Vakinankaratra and southeastern coast (BVPI-SE/HP project). The aim is to adapt technical and organizational messages to farmer realities and promote innovation processes including direct seeding mulch based cropping systems (DMC) for sustainable production as well as the integration of agriculture and animal production. A self-appraisal method for farmers'groups and a network of reference farms have been developed. These tools can also be used to assess technical actions and provide support in defining aspects of public agricultural development policy.

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Identifying innovation processes

Cowpea mulch in a DMC system with a maize-cowpea-rice rotation, Madagascar. © E. Penot, CIRAD

CIRAD proposes self-appraisal sessions where farmers in producer organizations themselves identify innovation processes adapted to them, using the "Accelerated Propagation of Innovation" (API) method (Belloncles). The method requires prior coaching of the participants so that they can give thought to a situation then act appropriately. This prior coaching is provided by socio-organization specialists.
At Lake Alaotra, CIRAD used the API method with associations of irrigation water users, the federation of user associations in the network of the two irrigated areas: "PC15" and "Marianina Valley", as wall as with agricultural intensification groups and farmer groups integrating DMC practices. The transmission of technical information within the farmer groups applying DMC was a frank success. The analysis identified how DMC techniques are effectively adopted and revealed a potential will to increase intensification from the 4th or 5th year of DMC.

The development project partners thereby acquired experience in organizing and running these sessions. The method has been formalized in the form of a BV-lac working document available from CIRAD.

On-farm reporting-back session, Madagascar. © E. Penot, CIRAD

Developing a network of reference farms

New cropping systems are assessed in networks of reference farms. A network of reference farms is a set of farms representative of different agricultural and socio-economic situations. The farms are monitored annually, to measure the impact of technical actions and development policies and carry out prospective analyses.

Olympe software is a tool developed by CIRAD, INRA and IAMM (Mediterranean Agricultural Institute in Montpellier) to simulate farm activities. It can be used to test the robustness of a technical choice, and farm's resilience when faced with a series of hazards. Simulations of the adoption of new techniques are carried out with standard crop management patterns that provide reliable data over a large number of plots through prospective analysis. Applying this approach to the adoption of direct-seeding mulch-based cropping systems at Lake Alaotra helped development operators to make progress in their work. Consequently, the technical possibilities offered to famers have become more adapted to the constraints faced by different types of farms. In particular, the levels of cropping system intensification proposed are more adapted to risk levels acceptable to producers.

Partners

- FOFIFA, Centre de recherche agronomique de Madagascar
- University of Antananarivo, Madagascar
- Development partners associated with the BV-Lac and BVPI-SE/HP projects, Madagascar
- Groupement semis direct de Madagascar

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Conservation of fertilizer resources within animal production systems in southern countries

Changing farming practices

In mixed crop/livestock farming systems, the biomass produced on farms (livestock effluents, crop residues, natural vegetation), which were previously put aside or burnt, are now used to restore soil fertility, supplement mineral supplies and produce feed and forage resources for animals. In effect, farmers are finding it increasingly difficult to access inputs. Within this context, using and recycling livestock effluents is the main source of nutrient return to agricultural plots. In the near future, it will be necessary to see these effluents as a resource, and no longer as waste.

Incorporation of manure into the soil (Antsirabe, Madagascar). © Paulo Salgado/CIRAD

Collecting manure after 60 days' storage in a covered heap (Antsirabe, Madagascar). © Paulo Salgado/CIRAD

An unrecognized role played by animals: boosting soil fertility

All the stakeholders involved in development and agricultural research agree on the need to increase crop and animal production system efficiency through appropriate use of plant and animal biomass produced on farms, or available in the surrounding environment. However, above all, farmers are now aware of the need to restore or maintain the fertility of their fields in the long term if they want to ensure their own food security or profitable production activities.

In effect, as a result of population growth, land is increasingly rare and areas whose fertility was often low to begin with are being used without any fallow periods, hence a decline in their fertility. Given this situation, animals are an essential tool for improving soil fertility by virtue of their ability to integrate, convert, use and recycle nutrients (nitrogen and phosphorus). However, although farmers are generally relatively familiar with livestock effluent production and management, very little research has been done on improving fertilizer value and nutrient conservation.

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An example: nitrogen transfer within a farm

Thought needs to be given to nutrient conservation at every stage of the transfer cycle from animal to animal:

1. Production of livestock effluents. A fraction of the dietary nitrogen consumed by animals is excreted in their faeces and urine. Those effluents may remain in the enclosure (flow a) and/or within the rangeland (flow b), depending on the animal management method.

Nitrogen transfers within a farm. Based on Rufino et al., 2006

2. Effluent collection and management. The effluents are collected (flow c) and applied directly on cultivated land (flow d) or stored (flow e); crop residues may be added (flow f) during storage.

3. Nitrogen mineralization in the soil, its fixation and conversion by plants. Effluents are spread on cultivated land (flow g); the plants absorb the mineralized fraction of the nitrogen, which is the only fraction available (flow h). The nitrogen absorbed by the plants is shared between the grain and vegetative parts (flow i). Crop residues not used by man can be used to feed animals (flow j).

The impact of farming practices

In the highlands of Madagascar, CIRAD has established research operations to identify farming practices linked to the fertilizer value of manure and assess the efficiency of nutrient conservation on mixed crop/livestock farms. The research is supported by surveys and on-farm monitoring operations, and by characterization of the chemical composition of effluents (near-infrared spectrometry). These tools have been used to assess on-farm nitrogen flows and transfers and study the impact of farming practices on the fertilizer value of livestock effluents.

The results show that paving the floor of stables, adding rice straw to litter, storing manure in pits, adding pig or poultry slurry and reducing storage times are some of the main practices that boost the nitrogen value of manure. These results are vitally important for advising farmers on how to produce quality organic fertilizer and improving fertilization techniques within a context of low-input farming systems.

These improvements not only help to increase food self-sufficiency and farming household incomes, but also to reduce their reliance on external inputs, the prices of which greatly depend on market volatility. Moreover, reducing mineral fertilizer use helps to improve the environmental efficiency of agricultural activities (reduction in greenhouse gas emissions and fossil fuel consumption).

A paradoxical situation

Lastly, global agriculture now finds itself in a paradoxical situation: whereas in the case of intensive animal production in temperate regions, the nitrogen produced by farms is seen as a pollutant and it is generally accepted that the quantities produced need to be cut, the situation is quite different on family farms in tropical zones, where it is a resource to be kept on the farm at all costs.


Using rice straw to feed zebus (Moramanga, Madagascar)
© Paulo Salgado/CIRAD

Partners

- **Madagascar:** SPAD research and training platform in partnership; FIFAMANOR, Centre de développement rural et de recherche appliquée; TAFA, Terre et développement; GSDM, Groupement semis direct de Madagascar; LRI, laboratoire des radio isotopes.
- **Burkina Faso:** ASAP research and training platform in partnership; CIRDES Centre international de recherche-développement sur l'élevage en zone subhumide.
- **Senegal:** PPZS research and training platform in partnership; ISRA, Institut sénégalais de recherches agricoles.
- **Kenya:** ILRI, International Livestock Research Institute.
- **France:** INRA, Institut national de la recherche agronomique; AFD, Agence française de développement.

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Sustainable charcoal production in the Democratic Republic of Congo


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Improved tree fallow

Kinshasa, the capital of the Democratic Republic of Congo, has a population of 8 million inhabitants and consumes up to 6 million tonnes of bio-energy equivalent per year. The city is surrounded by grasslands and patches of forest. The bio-energy used by the urban households consists mainly of fuelwood (charcoal and firewood). Charcoal needs, but also most of the staple starchy foods in the diet (cassava and maize) are provided by slash-and-burn shifting cultivation and by carbonization of the patches of forest and tree savannahs, which continue to deteriorate. Production obtained from these tree stands is becoming scarce and expensive. Soil fertility is declining, crop yields after fallow are decreasing, springs are drying up and fires are increasingly frequent. How can these populations continue to be supplied whilst limiting the environmental impact on forests?


Forest on the slopes of the Bateke plateau being cleared for charcoal production and farming. © R. Peltier, CIRAD

Improving tree fallow

Slash-and-burn cultivation gives rise to tree fallow after one to three years of cropping, due to the exhaustion of soil reserves. Improving tree fallow consists in planting tree legumes, whose roots combined with microorganisms fix atmospheric nitrogen. Organic matter and nitrogen storage in the soil is thereby accelerated. This is especially true for acacias, trees that are also known for their large biomass/wood production. The trees can already be planted during the cropping period and continue to grow rapidly after harvesting during the fallow phase. Since the 1990s, CIRAD has bred more specific tree species associated with symbiotic bacteria (rhizobium) that display strong growth and nitrogen fixation, particularly in Ivory Coast and the Republic of Congo. Since 2009, CIRAD has been implementing the EU-funded "Makala" (research development project about the fuelwood sector), and intends to disseminate these improved tree fallow techniques and provide sustainable management techniques for the last remaining patches of forest around Kinshasa.

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The Mampu tree fallow

Reforestation of degraded grassland, mainly with *Acacia auriculiformis*.
© R. Peltier, CIRAD

The Mampu plantation, about 140 km east of Kinshasa, was originally designed as the pilot phase in a vast reforestation project covering 100,000 hectares of sandy soils on the Bateke plateau. Between 1987 and 1993, 8,000 hectares of Acacia auriculiformis were planted by two EU-funded projects. From 1994 onwards, the Mampu plantation was divided by the Hanns Seidel Foundation staff into plots of 25 hectares allocated to 320 farming families. Farmers were required to manage their new tree plantation following a novel agroforestry technique that combines food crops with acacia. Two or three years after planting the trees, once agricultural products have been harvested, the acacias reach a height of three metres. After around ten years, a veritable acacia forest, mixed with a few local species, becomes established. Farmers can then exploit it, process the wood into charcoal and sell it in town. In the unharmed humus, they can replant a new crop cycle. Every 4 metres, a one metre wide strip of soil is left unfarmed, so that acacia seeds can germinate and reconstitute the future forest stand.

Total charcoal production from the plantation currently varies from 8,000 to 12,000 tonnes per year (t/year). In addition, the farmers produce 10,000 t/year of cassava, 1,200 t/year of maize and 6 t/year of honey. Reforestation of the Mampu stand is considered a success.

Cassava harvest after slash-and-burn cultivation in an acacia plantation, and processing into chips.
© R. Peltier, CIRAD

Increasingly efficient charcoal makers.
© R. Peltier, CIRAD

Extension to the Bateke plateau grasslands

The Mampu agroforestry model is to be extended to the villages located in the Bateke plateau grasslands. Special attention is paid to the role of traditional land rights and the possible diversification of other products and local processing techniques. Overall, this should increasingly contribute to meeting urban renewable energy needs, whilst creating rural jobs.

Moreover, other agroforestry systems, under other ecological and socio-economic conditions, are worth testing; such as managing the natural regrowth of local multipurpose species (for fruits, wood, shelter for game, nitrogen fixation, etc.). Indeed, on more clayey land once occupied by forest, there is a great variety of tree species in the natural regrowth. Those trees cannot develop due to continual felling and uncontrolled fires. If the plot is covered by a thicket, a farmer can first protect it with a fire-break, then select 100 to 400 sprigs per hectare of useful species out of the thousands of shoots. After 8-10 years of protection, the plot can then be used to harvest fuelwood and to plant crops, whilst maintaining a few large trees for seed production (10 to 100 per hectare) for the next production cycle.

Partners

- CIFOR, Center for International Forestry Research, Cameroon
- CRDPI, Centre de recherche sur la durabilité des plantations industrielles, Congo
- European Union (EuropAid)
- Hanns Seidel Foundation, Germany and Democratic Republic of Congo (DRC)
- Kisantu botanical garden, DRC
- Liège-Gembloux University/Agro-Bio Tech, Belgium
- National Reforestation Services, DRC and Republic of Congo
- University of Kisangani, Ecole régionale post-universitaire d'aménagement et de gestion Intégrée des forêts et territoires (ERAIFT), DRC

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Forests as an energy source

Supply chains and processes that serve development

In addition to vital domestic energy (80 to 90% of the energy used to cook food in Africa is still derived from wood), developing countries also need to generate energy for production purposes. Using biomass–agricultural and forest products or waste–offers just such an opportunity, and is compatible with sustainable resource management. It would also serve to reduce these countries' dependence on fossil fuels and to reduce greenhouse gas emissions.

Storing eucalyptus chips prior to transport, port of Pointe-Noire, Republic of Congo.
© JM. Bouvet, CIRAD

Three quarters of the world's inhabitants live in developing countries, but their primary energy consumption comes to just 35% of the global total. However, there is abundant biomass available in many of these countries. This renewable resource could be an opportunity for developing the production sector, above and beyond the need to satisfy domestic energy demand.

Biomass conversion into energy needs to be optimized by adopting efficient conversion processes, using technologies tailored to the materials available, the socioeconomic situation and the local environment. This is what determines whether bioenergy is indeed a force for development and serves to reduce poverty and improve energy self-sufficiency in the South.

Developing supply chains suited to requirements in the South

Developing efficient biomass energy supply chains while improving food security and resource sustainability is the challenge now faced. There is also a need to define the appropriate scales and organizational methods to ensure that such supply chains benefit local people, in both economic and social terms.

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CIRAD's work centres on:

- assessing the resource: the aim is to develop methods of assessing biomass production potential or the volume of agricultural waste available for energy, in view of the multiple uses of those resources;
- identifying supply chain development scenarios on a local, territorial and national scale: balancing demand, resources, technologies and the socioeconomic environment;
- organizing fuel markets and supplies to energy generating plants;
- comparing the economic, social and environmental impacts of the available technological alternatives;
- conducting environmental assessments of biomass energy supply chains, notably using life cycle analysis tools.

1000-kW steam turbine in a sawmill in Belem, Brazil © F. Pinta, CIRAD

Masonry carbonization oven, Democratic Republic of Congo. © F. Pinta, CIRAD

Adapting processing techniques to the type of biomass

Using miscellaneous agricultural or forest waste in the same process raises problems as regards co-product yields, reliability and management for conversion into energy. CIRAD is working to develop thermochemical processes that produce homogeneous solid, liquid or gaseous fuels that are easier to transport and use:

- **gasification** produces a fuel gas for use in motors, to generate electricity and to co-generate electricity and heat;
- **rapid pyrolysis** produces a liquid fuel with similar energy properties to those of the initial biomass, but in a smaller volume and a more easily usable form;
- **torrefaction** produces a solid fuel somewhere between the initial biomass and its charcoal, which has several advantages: it is dry, friable, can be finely crushed and is thus easier to use, as the particles are fluid; it emits fewer volatile compounds when burnt;
- **carbonization** produces charcoal that is used to cook millions of people's daily food. It can also be used in industry, for instance steelmaking.

CIRAD's research is aimed at ensuring a better understanding of the reaction mechanisms involved, with a view to developing efficient processes. It consists in:

- identifying the factors that limit conversion reactions;
- modelling reaction kinetics and heat and matter transfers on a particle and biomass bed scale;
- identifying and quantifying the effect of the type of biomass on reactions;
- identifying and quantifying the reaction co-products, understanding how they form, and limiting their production during the reaction.

Hearth of a wood-fired boiler producing steam to drive a turbine, Brazil. © F. Pinta, CIRAD

Partners

Africa

- 2IE, Institut international d'ingénierie de l'eau et de l'environnement, Burkina Faso
- ADER, Agence de développement de l'électrification rurale, Madagascar

Latin Ameria

- Brazilian forestry service, University of Pará, University of Brasilia, University of Campinas, Brazil
- CATIE, Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica

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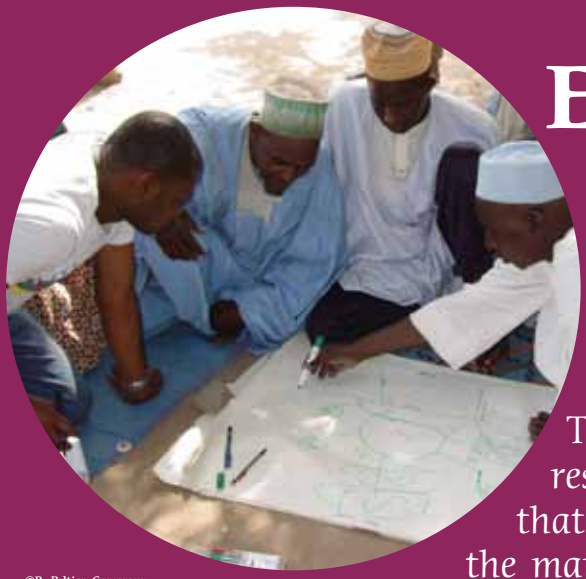

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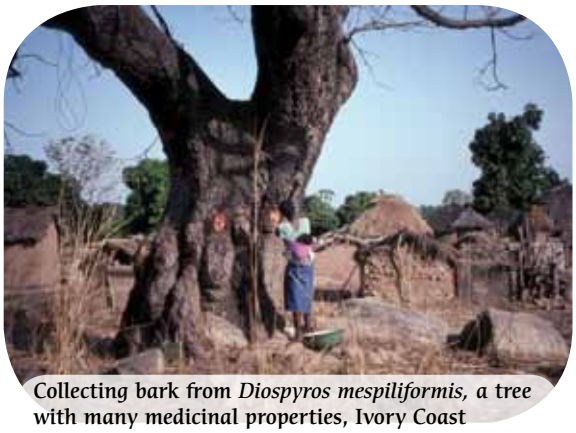
Ecosystem services

Unique economic and policy instruments

Throughout history, economic development has often resulted in the degradation of ecosystems, a phenomenon that has gained pace since the 1970s. However, ecosystems are the mainstay of life on Earth and contribute to the wellbeing of mankind. The ecosystem service concept was introduced in the 1990s to make this clear. In a world in which more than six billion people are looking to feed themselves and fulfil their hopes of a better future, CIRAD faces a major challenge: satisfying demand through crop and animal production while conserving the ecosystems that underlie our very existence. One of the fields CIRAD is working in with a view to solving this problem is research on ecosystem services.



Collecting bark from *Diospyros mespiliformis*, a tree with many medicinal properties, Ivory Coast
© D. Louppe, CIRAD

An environmental, economic and policy issue

The ecosystem service concept was developed to satisfy the need to understand the interdependence of ecosystems and society. Ecosystem services are defined as the benefits people obtain from ecosystems. For instance, the leaves and roots of trees control erosion, limit biodiversity losses and maintain river water quality while reducing the cost of water treatment. Tropical forests play a role in the formation of precipitation on a regional level, in the Amazon, the Congo Basin and Indonesia. Genetic biodiversity is a source of medicines, contributes to disease control and sustains genetic potential for the future.

Naturally, the aim of the ecosystem service approach is not to reduce nature to its role as a support for mankind. On the contrary, it is intended to help in developing an interdisciplinary approach in which aspects linked to socioeconomic governance and knowledge of biophysical processes are taken into account in a coordinated way, enabling the implementation of strategies on a national, regional and local level, for each and every type of stakeholder.

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Interdisciplinarity, a source of excellence

Assessing ecosystem services in highland forest agro-landscapes
© D. Ezzine-de-Blas, CIRAD

CIRAD's specificities, in terms of its history, professional profile and operations (agriculture, development, conservation) and its global partnerships, mean that it has access to scientific expertise and technical solutions in the fields of both biophysics and socioeconomics. That expertise tallies with the various social and spatial scales on which solutions may be found to issues relating to conservation and development in tropical regions. It centres on three main lines of research:

- The assessment, conservation and restoration of ecosystem services

Integrated approaches are being developed to tackle the processes of erosion and of soil fertility maintenance; measuring carbon and carbon flux in tropical forests, agroforests and other cropping systems (including plantations); hydrological regulation in forests and farming systems; and use of biodiversity for pest management. These scientific advances form the foundations of innovative crop management techniques aimed at boosting agricultural and forest production (projects: Acaciagum, TropSoil&Biol&Fertility, Funcitree, Innovkar, Intensifix, Floresta em Pê, Floagri, etc).

Installation to study rainwater flow, Congo
© D. Louppe, CIRAD

– Analyses of policies and instruments to promote ecosystem services

CIRAD has global expertise in terms of analysing the scientific and policy issues that surround the ecosystem service concept: conception and implementation of environmental and rural development policies for the promotion of environmental services; and methodological tools applied to multi-criteria measurement of the socioeconomic and environmental impact of such policies. It also studies stakeholder networks and coalitions involved in promoting such approaches, their alliances and the resulting changes in the different international arenas and the public development aid sector (projects: Serena, Pesmix, Invaluable, Payer pour l'environnement ?, Prigou, Impact certification, etc).

– Modelling and foresight exercises

The science-policy interface is a priority line of research for CIRAD. To this end, CIRAD studies the socio-ecological systems behind the maintenance and restoration of ecosystem services. It addresses and explores the functioning and dynamics of such systems using modelling tools and participatory and foresight techniques (projects: EcoAdapt, Regreening Sahel, Prospective Bassin du Congo, Spiral, etc).

An essential approach for sustainable agro-ecosystem management

This expertise, at the interface between targeted and fundamental research, enables CIRAD to help develop and implement new crop management techniques, draft guides to good practice and design agro-ecosystem management plans on a local, regional and global level.

Partners

CIRAD is involved in numerous projects on every continent.

For further information

Project websites:
http://inco-acaciagum.cirad.fr
http://inco-innovkar.cirad.fr
http://www.serena-anr.org/
http://pesmix.cirad.fr/
http://www.programme-repere.fr
http://www.afriseb.net/)

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Geographical indications

to promote local products

Darjeeling © B. Bridier, CIRAD

In the face of globalization, greater competition on the major export markets, and price instability, promoting reputed, highly specific local products is an approach worth exploring. It responds to consumer demand in the North and also, increasingly, in the South. It serves to guarantee outlets and allows producers to move into increasingly profitable niche markets.

Oku honey, Cameroon © D. Chabrol, CIRAD

The recognition of geographical indications (GIs) by the World Trade Organization in 1994 led many countries to establish a legal framework to protect their traditional local agricultural and craft products.

In Europe, and particularly in France and Italy, where they go back a long way, GIs and designations of origin (PDOs) have allowed many products to be recognized and appreciated for their specificity. They have helped sustain activities and jobs in less favoured areas. Contrary to other specific quality approaches (organic, fair-trade, etc), in this case, it is the producers who determine the relevant specifications. Unlike brand names, it is not necessary to go to court to ensure those specifications are respected (at least in the EU, but also in many other countries).

However, to what extent is the approach suited to developing countries, and is it useful in alleviating rural poverty? How can the target products truly be protected and promoted?

Tackling the challenges of rural development and poverty alleviation

CIRAD has worked in a range of situations and with various partners, enabling it to acquire substantial experience, which is also the object of research work and training operations.

Its Innovation Joint Research Unit (UMR Innovation) is continuing with its dual approach of analysing and supporting innovation processes, which is allowing family farmers to gain a foothold on agrifood markets and helping to build new relations between food and territories.

It has participated in research projects, and produced or supervised theses on the range of GIs worldwide: India, East Africa, Brazil and Southeast Asia.

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This work has shown that the "geographical indication" legal device is not suited to some situations and that certain conditions are required if it is to benefit sustainable rural development.

For instance, there are several vital stages when building a GI:
› the prior reputation of the product and awareness among producers of its specificity and value;
› the identification and construction of dialogue between producers, leading to the founding of a representative organization;
› the collective drafting of specifications, supervised by such an organization, taking care not to exclude the poorest or most disadvantaged farmers (technical support, schedules, etc);
› the implementation of an internal auditing system, validated by external audits, so as to generate and sustain confidence among producers

Tour of a cooperative producing PDO pélardon cheese in the Cévennes
© D. Chabrol, CIRAD

Tailor-made training courses

Each year, in partnership with the Swiss REDD team, UMR Innovation organizes a two-week training course for staff responsible for recording GIs at the authorities in charge of intellectual property, professional leaders from the supply chains concerned, and rural development leaders and experts (www.intergi.org). The course covers legal as well as economic, social and organizational aspects. It centres on interactive methods: the participants present their experiences and work in groups on case studies. They visit two GIs during each session and benefit from contributions from top-level European and international experts. The course is held in English and has attracted participants from many countries, including Brazil, Indonesia, India, Pakistan, China and Vietnam. Other courses could be organized on the same bases, maybe shorter or for specific audiences (notably French speakers).

Project support

Bolovens coffee, Laos © B. Sallée, CIRAD

CIRAD's expertise has been put to good use in several ways:
› support of Kintamani coffee in Bali (2005-2009), which became the first Indonesian GI;
› leadership of a GI pilot project in Laos (2007-2010): a law has been drafted and two products are ready to be registered for GIs;
› technical support of the 16 AIPO member countries: training, communication, recording GIs (Oku honey and Penja pepper in Cameroon, Ziama Macenta coffee in Guinea) (2010-2013); projects under way in Tunisia (Gabès pomegranates, Tunisian Deglet Nour dates, Tebousouk olive oil) and in Kenya (coffee);
› training, research, project support (Brazil, Vietnam);
› supervision of PhDs or Masters.

Partners

- **Indonesia, Laos, Tunisia:** relevant ministries
- **Africa:** AIPO, African Intellectual Property Organization
- **Kenya:** Coffee Research Council
- **France:** Ministry of Foreign Affairs, Ministry of Agriculture; AFD, Agence française de développement; FFEM, Fonds français pour l'environnement mondial; INAO, Institut national de l'origine et de la qualité
- **Switzerland:** REDD, Sharing knowledge for ethical and tasty food

For further information

To download:
CIRAD, 2012. Perspective No. 17. Geographical indications for agricultural and handicraft goods: the strength of a link to the origin as a criterion
FAO, 2009. Linking people, places and products 189 pp.
AFD, FFEM, 2010. Indications géographiques : qualité des produits, environnement et cultures. 104 pp.
CTA – Origin, 2011. Manuel pratique sur les IG pour les pays ACP. 67 pp.

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